

0 **Title: WOOD FIBER POLYMER COMPOSITE EXTRUSION AND
 METHOD**

TECHNICAL FIELD

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 The invention relates to a composite polymer/wood
fiber extrusion and a method for making the same. More
specifically, the invention relates to a foamed
cellulosic/polymer extrusion and a method for making the
10 same.

BACKGROUND OF THE INVENTION

 Composite wood fiber/polymer extrusions have been
15 available for a number of years. The art with respect to
the manufacture of such extrusions, particularly combining
wood fibers having a mesh size between approximately 40
mesh and 80 mesh, and thermoplastic polymers, primarily
polyolefins is well developed. An early application for
20 such a composite related to the extrusion of a mixture
comprising 50% by weight wood fiber and 50% by weight
polypropylene for use in car door panels and other
interior automotive parts. This process had significant
economic advantages, particularly in the early 70's when
25 wood fiber was essentially a low or no lost waste product
from wood processing facilities and the price of petroleum
was relatively unstable. Extruders could vary the
percentage of waste wood, cellulosic material in the
extrusion depending on the price of polypropylene feed
30 stock which was, of course, dependent upon the price of
oil. Other extruders recognized not only the economic
merit of such a product but also recognized that a variety
of wood only products, such as decking, pallets, and
containers could be replaced with wood/thermoplastic
35 extrusions because the price of virgin wood was climbing
rapidly. Extruders eventually acquired the ability to co-
extrude waste wood products with polyvinyl chloride

0 thermoplastics as well as polypropylenes and polyethylenes.

Problems relating to co-extrusion of wood fibers and a thermoplastic polymer component are well explained in United States Patent No. 5,851,469 to Muller et al. issued December 22, 1998, the disclosure of which is incorporated
5 herein by reference. Muller et al. described the typical prior art steps for co-extruding a thermoplastic polymer with wood fiber. In a first step, the wood fiber is dried using conventional techniques to a moisture content of less than 8% by weight. In a second step the wood fiber
10 and plastic material are preheated to a temperature of approximately 176° F. to 320° F. In a third step, the materials are mixed or kneaded at a temperature of 248° F. to 482° F. to form a paste. In a fourth and final step, the paste is either injection molded or extruded into a
15 final form. If the paste is extruded, the extrudate must be calibrated and cooled. The Muller et al. reference specifically addresses the problem of controlling the temperature of the extrudate through various stages of the extrusion process to prevent undesirable sheer stresses from arising during the extrusion process. Muller et al.
20 also teach that a particular problem involved with wood fiber/thermoplastic composite extrudates involves volatiles in the wood component boiling off at extrusion temperatures causing an undesirable foaming of the extrudate.
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U.S. Patent No. 5,746,958 to Gustafson et al. further explains that particularly when using post-consumer polymers (usually polyethylenes) the vagaries of the characteristics of this component, when combined with the
30 problem of wood volatile boil off creates difficulties in producing a uniform composite extrudate. Specifically, Gustafson et al. teach that a high volume extruder must be fed a minimum volume of a continuous product (e.g. feed stock) stream. To satisfy this demand within the
35 parameters of the problem discussed above, Gustafson et al. teach a method of pelletizing the thermoplastic

0 component so as to produce a uniform feed stock having
known characteristics. Two or more different
thermoplastic, pelletized feed stocks are provided and
then blended with wood fibers to produce an extrudate
having consistent quality characteristics. The disclosure
5 of the '958 patent is incorporated herein by reference.

U.S. Patent No. 5,425,954 to Wold describes methods
for molding wood fiber/thermo-setting resins to produce
oriented strand board type products and is thus
illustrative of the differences between continuously
10 extruding thermoplastic wood fiber/thermoplastic
extrusions and hot press molding of wood fiber/thermo-
setting composite products. U.S. Patent No. 5,759,680 to
Brooks is believed to disclose the current state of the
art for preparing a wood fiber/thermoplastic extrusion
15 suitable for use in the building trades.

U.S. Patent No. 5,486,553 to Deaner et al. discloses
a polymer/wood thermoplastic composite structural member,
suitable for use as a replacement for a wood structural
member, such as for window components. The preferred
20 thermoplastic component is polyvinyl chloride (PVC) and
sawdust. In a preferred embodiment of the invention, a
double hung window unit is disclosed having cell, jamb and
header portions comprising hollow, multi-compartment
lineal extrusions which can be made from the disclosed
25 thermoplastic polymer/wood fiber composite. The resulting
extrusion has mechanical properties which are similar to
wood, but have superior dimensional stability, and
resistance to rot and insect damage as compared to
conventional wood products.

30 In addition to the above prior art, it is known that
foamed PVC/wood fiber composite extrusions have been
prepared. A foamed extrusion substantially reduces the
amount of polymer necessary per unit volume of extrusion
because the foaming process produces a plurality of
35 interstitial voids within an otherwise solid extrudate in
cross-section. One disadvantage of this type of extrusion

0 is that the flexural modulus for this type of a foamed PVC
product is relatively low (e.g. 170,000) whereas the
flexural modulus for ponderosa pine is typically 900,000.

Hollow, extruded profiles can be manufactured with
webs and other internal structural members to produce
5 virtually any desired macroscopic mechanical property.
However, in extrusions having an extremely high aspect
ratio in cross-section (e.g. slats for Venetian style
blinds) it is mechanically impossible to provide the
extrudate with a wall thickness sufficient to provide the
10 desired macroscopic mechanical characteristics,
particularly bending moment. In this area of product
application, a product having a solid cross-section from
a foamed material is preferred. Unfortunately, prior
attempts to introduce wood fiber into a foamed polymer
15 extrudate demonstrates that the wood fiber tends to
counteract the effect of the foaming agent. As a result,
such prior art foamed PVC/wood fiber extrusions have
limited the wood fiber content to 5% by weight or less.
Such a small wood fiber component does little to reduce
20 the petroleum product content or to improve the mechanical
properties of the extrudate.

Nevertheless, a need exists for a composite extrusion
having a thermoplastic component and a wood fiber
component which uses substantially less thermoplastic
25 component per unit weight of finished extrusion as
compared to the products made by the processes described
above in the prior art. In addition, a need exists for a
thermoplastic polymer/wood fiber composite extrusion which
is sufficiently rigid to supplant standard solid wood
30 components in a variety of installations such as Venetian
style window shades and blinds.

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SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a foamed, continuous thermoplastic/cellulose fiber composite lineal extrusion employing a styrene acrylonitrile (hereinafter "SAN") component, a cellulosic material component and acrylonitrile butadiene styrene (hereinafter ABS) resin and a foaming agent.

In a preferred embodiment of the invention, the extrudate is prepared from a feed stock material comprising approximately 70% to 90% by weight SAN, approximately 5% to 25% by weight cellulosic material, approximately 2% to 27% by weight ABS resin and a trace amount of lubricant and foaming agent. The SAN feed stock component is preferably pelletized with the cellulosic material and is introduced into a conventional multi-screw extruder and various ratios of medium molecular weight, high molecular weight, and ultra-high molecular weight SAN with the ABS resin. The foaming agent is preferably injected down stream from a mixing a unit for the above components and upstream of a forming die connected to the extruder. The extrusion is then preferably calibrated to the desired size and shape.

An extrudate prepared by the inventive method preferably has a heat deflection temperature rating of not less than 170° F., a flexural modulus of at least 307,000 psi, a coefficient of thermal expansion of not more than approximately 3.33×10^{-5} inches per inch per degree Fahrenheit, and a thermal conductivity rating of not more than approximately 0.6 BTU inch per hour ft² square degree Fahrenheit. The preferred cellulosic material is wood fiber having a mesh size in the range of 40 mesh to 200 mesh, and in the preferred embodiment having a size of approximately 60 mesh.

The invention has particular utility with respect to extrusion profiles having a relatively high aspect ratio in cross-section, such as slats for Venetian style blinds.

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BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an environmental, isometric view of a high speed polymer extrusion apparatus for use with the method of the present invention.

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Figure 2 is a schematic representation in block diagram form of the process of the present invention.

Figure 3 is an enlarged, cross-sectional view of an extrudate manufactured by the method of the present invention.

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Figure 4 is an alternate embodiment of the extrudate.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A conventional, twin screw extruder for use with the method of the present invention is generally indicated at reference numeral 10 in Figure 1. The extruder 10 includes a hopper or mixer 12, for accepting a feed stock consisting of a thermoplastic polymer/ wood composite pelletized material, a conduit 14 for connecting the hopper with a preheater 16 for controlling the temperature of an admixture of the feed stock in the hopper 12, and an inlet 18 for introducing a foaming agent. The preheater 16 is connected to a multi-screw chamber 20 for admixing the feed stock with the foaming agent and other conditioners to be described herein below under controlled conditions of temperature and pressure. Chamber 20 is connected to an extrusion die 22 which produces an extrudate 24. The extrudate is preferably calibrated in a conventional calibrator 26 to result in a final product shown in Figures 3 and 4. An appropriate extruding machine 10 is available from Cincinnati Millacron Corporation, Cincinnati, Ohio, USA.

The extruder 10 and calibrator 26 are conventional apparatus, the operation of which is well understood by those of ordinary skill in the thermoplastic polymer extrusion art. The extrudate 24 shown in Figure 3 is a

0 foamed, continuous thermoplastic/cellulose fiber composite
lineal extrusion adapted for use as a slat or louver in a
window blind construction, commonly referred to as a
Venetian blind. The extrusion has excellent strength to
weight characteristics, and has a workability and surface
5 finish similar to a milled wood product from a coniferous
tree, such as ponderosa pine. The extrusion has a heat
deflection temperature rating of not less than 170° F., a
flexural modulus of approximately 307,000 psi, a
coefficient of thermal expansion of not more than 3.33×10^{-5}
10 $\text{inch per inch per degree F.}$, and a thermal
conductivity rating of not more than approximately 0.6
BTU's per hour per $^{\circ}\text{F}^2$. The extrusion preferably also has
a density of not more than approximately 0.6 grams per cm^3 .

The extrusion produced by the method of the invention
15 has particular utility with respect to an extrudate, such
as that shown in Figure 3, having a high aspect ratio in
cross-section. Such high aspect ratio extrusions are
often difficult to form as a conventional hollow extrusion
having the desired macroscopic physical properties of
20 bending moment, workability, screw retention, etc., in a
cost effective manner. Stated another way, it is
difficult to produce a very narrow, hollow extrusion
having a high bending moment, and good screw retention
without employing a complex web structure within the
25 extrusion and pre-drilled screw holes. While such
structures are technically possible to incorporate in a
hollow extrusion, these features increase the raw material
cost, wall thickness, and engineering complexity of the
die used to produce the extrusion. A foamed extrusion can
30 be produced which uses significantly less polymer
component per unit length of extrusion than a high aspect
ratio engineered hollow extrusion having similar
macroscopic physical characteristics.

The assignee of the present invention has discovered
35 that it is possible to produce a foamed thermoplastic
extrusion having wood fiber as a significant component

0 thereof. Prior attempts to produce a foamed extrusion
having wood fiber as a significant component have been
unsuccessful, as the wood fiber tends to degrade the
effectiveness of conventional foaming agents. In
particular, polyolefins such as polyethylene and
5 polypropylene do not adhere well to wood and significant
modifiers are needed (usually a thermo-setting resin, 2%
to 3% by weight). Polyvinyl chloride (PVC) bonds well to
wood fibers because like wood fibers it is a polar
molecule. Unfortunately, prior attempts to foam a PVC/
10 wood fiber composite extrusion have only been successful
wherein the wood fiber component is 5% by weight or less.
In such low ratios, the wood fiber has little structural
effect on the resulting extrusion and does not achieve any
of the significant advantages of a wood fiber/thermo-
15 setting polymer extrusion, including rot resistance,
paintability, stainability and workability characteristics
similar to a milled wood product such as pine. It is an
aspect of the present invention that, contrary to
conventional wisdom, a foamed thermo-plastic polymer/wood
20 composite extrusion can be produced having a high
proportion of cellulosic material content in the form of
wood fiber in the range of 5% to 25% by weight wherein the
principal thermoplastic polymer ingredient is styrene
acrylonitrile (SAN) in the range of 70% to 90% by weight.
25 Table I illustrates one preferred formulation used for the
production of a foamed, thermoplastic/ cellulosic material
composite extrudate suitable for use as a slat in a window
blind, of the type shown in Figure 3.

TABLE I

INGREDIENT	PERCENT RANGE (by weight)
SAN	70-90
Wood Fiber	5-25
ABS	2-8
Lubricant	0.1-0.5
Foaming Agent	0.5-3

An appropriate SAN product is available from General Electric Specialty Chemicals, Morgantown, West Virginia, as well as from Kumho, South Korea. Specifically, the General Electric products Blendex 570, 576, and 869, as well as Kumho SAN 350 have proven satisfactory for this purpose. A suitable ABS component used as a modifier is General Electric's Blendex 360 product. A suitable foaming agent is available from Color Matrix of Cleveland, Ohio, under the designation 80-428-1. Magnesium stearate has been found to be a suitable lubricant. It is believed that ethylene-bis-stearimide and calcium stearate in the same proportions as given above are also suitable lubricants.

Substantial success has also been achieved by alloying different molecular weight SAN products. Another alternate formation is shown in Table II below.

TABLE II

INGREDIENT	PERCENT RANGE (by weight)
High Molecular Weight SAN	0-85
Medium Molecular Weight SAN	5-90
Ultra-High Molecular Weight SAN	1-5
Wood Fiber	5-25
ABS	2-8
Lubricant	0.1-0.5
Foaming Agent	0.5-3

It is preferred that the SAN/ wood fiber component be prepared as a pelletized feed stock for admixture with the ABS modifier, lubricant and foaming agent. An appropriate pelletized product is available from Northwoods Company, Sheboygan, Wisconsin. A typical wood fiber mesh size for this pelletized product is 60, but an acceptable range may be from 40 mesh to 200 mesh. The pelletized compound consists of 20% to 80% by weight medium molecular weight (MMW) SAN, 20% to 80% wood fiber, and 0.4% to 2.0% lubricant. A resulting general formula for extrusion is shown in Table III below.

TABLE III

INGREDIENT	PERCENT RANGE (by weight)
Northwoods Pellets	6-90
MMW SAN	0-85
HMW SAN	0-85
UHMW SAN	1-5
ABS	2-8
Foaming Agent	0.5-3

A particular preferred embodiment of the invention is shown in Table IV below.

TABLE IV

INGREDIENT	PERCENT
Northwoods Pellet	26
Kumho SAN 350	65
5 GE B-869 UHMW SAN (Stiffener)	2
GE B-360 ABS (Modifier)	5.2
Color Matrix Foaming Agent 80-428-1	0.8

In Figure 2, the SAN/wood fiber pelletized feed stock is added into the hopper or mixing unit 12, along with the additional Ultra High Molecular Weight (UHMW) SAN stiffening agent, ABS resin modifier and either Medium Molecular Weight (MMW) SAN or High Molecular Weight (HMW) SAN. The ratios of UHMW to MMW or HMW SAN can be varied in accordance with the skill level of the artisan to provide an extrusion having varying macroscopic physical properties. Once mixed, the resulting compound is gravity fed through the conduit 14 to the extruding chamber 20. The foaming agent is added on line by way of inlet 18 through a peristaltic pump Model CM100 manufactured by Color Matrix of Cleveland, Ohio. The pump speed can range from 7 rpm to 12 rpm according to the feed rate of the feed stock and speed of the mixer. The extrudate 24 appears at the exit of the extrusion die 22 in the desired form. An appropriate extruder 10 is a Model CM 55 manufactured by Cincinnati Millacron, Batavia, Ohio.

The extrudate 24 shown in Figure 3 can be used as wood product replacement in a wide variety of applications. One application utilized by the assignee of the present invention is as a slat for a window blind. Those of ordinary skill in the art will appreciate other applications suitable for the extrudate of the present invention when extruded in a variety of cross-sectional shapes. The extrudate has physical characteristics remarkably similar to ponderosa pine and superior to rigid PVC and foamed PVC products. Table V illustrates results

0 of tests conducted by the assignee of the present invention comparing various physical properties of the inventive extrudate manufactured by the method of the present invention compared to rigid PVC and two competitive foamed PVC products.

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TABLE V.

	RIGID PVC	1ST FOAMED PVC PRODUCT	2ND FOAMED PVC PRODUCT	INVENTIVE EXTRUDATE	INVENTIVE EXTRUDATE w/PVC Cap	PONDEROSA PINE
10 Heat Deflection Temperature ASTM D648	145°F	151° F.	153° F. (165° F.)	175°F.	165° F.	N/A
15 Vicat Softening Point ASTM D1525	190° F.	173° F.	179° F.	217° F.	219° F.	N/A
20 Flexural Modulus ASTM D790	390,000 psi	128,000 psi	257,000 psi	307,000 psi	220,000 psi	1,290,000 psi
20 Direct Screw Withdrawal ASTM D1037	456 lbf	242 lbf	291 lbf	527 lbf	319 lbf	163 lbf (ASTM D1761)
25 Hardness, Type 'D' Durometer	82	83	62	79	56	
30 Coefficient of Thermal Expansion	3.59 x 10 ⁻⁵ in/in/°F	(1.8 x 10 ⁻⁵ in/in/°F)		3.33 x 10 ⁻⁵ in/in/°F	3.19 x 10 ⁻⁵ in/in/°F	2.5 x 10 ⁻⁶ in/in/F °
Thermal Conduct- ivity ASTM D177	0.69 <u>btu-inch</u> ft ² -hr-°F		0.46 <u>btu-inch</u> ft ² -hr-°F	0.45 <u>btu-inch</u> ft ² -hr-°F		1.6-2.9
35 Water Absorption ASTM D1037	0.09%	0.45%		0.56%	5.16%	17.2%
Density	1.45 g/cc	0.69 g/cc	0.63 g/cc	0.51 g/cc		

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Figure 4 illustrates an alternate embodiment of the invention in which the extrudate 24 is co-extruded with a polyvinyl chloride cap stock 50. The cap stock is co-extruded in a manner well known to those of ordinary skill in the thermoplastic extrusion art.

Those of ordinary skill in the art will, upon reviewing the above disclosure conceive of other embodiments and variations of the invention. Therefore, the invention is not to be limited by the above description, but is to be determined in scope by the claims which follow.